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AN APPLICATION OF FLOATING CONSTRUCTED WETLAND REACTOR TO PHYTOREMEDIATION OF SEWAGE

Asmita B.Daspute-Taur, Renuka G. Thete-Jadhav, S.L.Jadhav, Shankar S.
Department of Environmental Science,
S.B.E.S. College of Science, Aurangabad-431004.

Shingadgaon
Department of Environmental Science,
School of Earth Sciences, Solapur University, Solapur-413255.

B. L. Chavan
Department of Environmental Science,
Dr.Babasaheb Ambedkar Marathwada University, Aurangabad-431001 (India).

ABSTRACT

To study the application of phytoremediation for the treatment of sewage, the Floating Constructed Wetland Reactor (FCBRs) of macrophyte Beds were designed and fabricated with plastic crates and locally available materials including macrophyte. The potential of Cyperus esculentus L was studied to serve as a phytoremediation plant in the cleaning up of contamination from polluted municipal sewage. The macrophyte Cyperus esculentus L were planted on the floating bed composed of thermocol sheets, stone crushed aggregates and river sand in turn and were floated in shallow basin sludge containers to study the

treatment efficiencies at different concentrations of sewage. The results showed that TSS, TDS, BOD and COD were reduced by 78.7%, 79.45%, 83.33%, 81.16% respectively in 40% sewage concentration followed by reduction in other concentrations. The results obtained and subsequent interpretation revealed that the design of Floating Constructed Wetland Reactor Systems are perfectly suitable for phytoremediation treatment of sewage using Cyperus esculenta L at all concentrations, with highest efficiency at about 40% concentration. It concluded that Phytoremediation with Cyperus esculenta L.using Floating Constructed Wetland Reactor system is an effective way to remove organic matter from the sewage, polluted rivers and other water bodies.

Experimental Methods:

Floating Constructed Wetland Reactor Systems were designed, fabricated and developed using plastic crates with the beds consisting of locally available and costless materials like thermocol sheets, stone crushed aggregates and river sand layers one after another in which the locally available plant of *Cyperus esculentus L.* was planted, acclimatized for sewage for a month and the used for treatment studies at various concentrations of sewage in the batch mode of operation. The rectangular basin made up of iron sheet was used as holding tank in which the floating constructed wetland reactor systems were floated.

The design prepared and layout of macrophyte planting is as shown in Fig.1 and 2. The experiments were conducted under the same operational and in same environmental working conditions and treatment efficiency in terms of percent reduction in TSS, TDS, BOD and COD were studied using standard methods (APHA, 2005) and compared with a set of control with dilution water operated simultaneously without sewage.

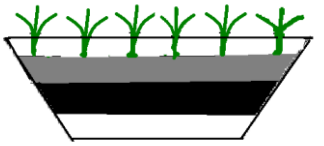


Fig. 1: Conceptual Design of Floating Constructed Wetland Reactor

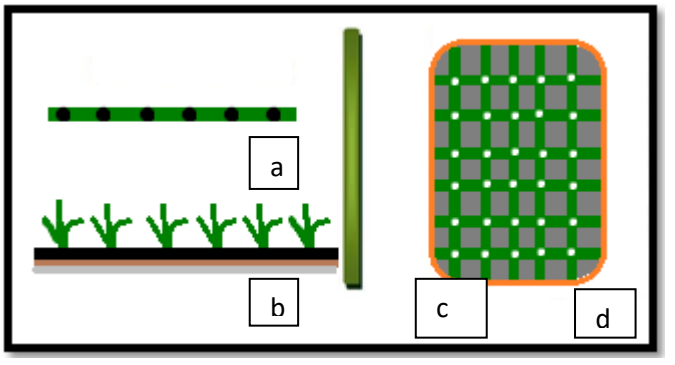


Fig. 2: Design views of planting points of *Cyperus esculentus L.* in floater bed of constructed wetland; a-points of planting, b-planting of saplings, c-symbolic column for planting and d- basal view from top indicating planting points.

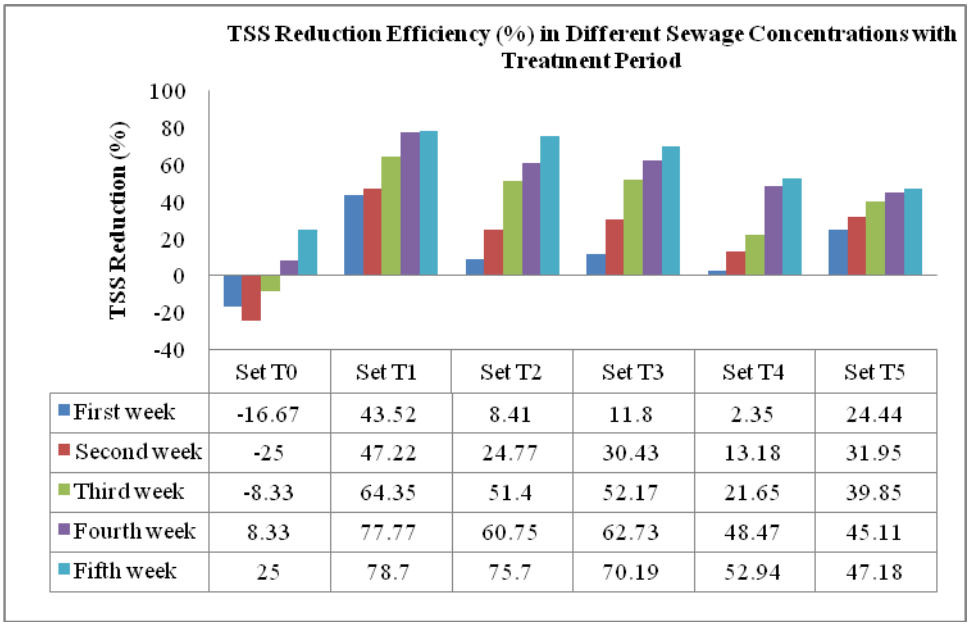
Results and Discussion:

Water pollution from different human activities, either industrial or domestic, is a major problem in many countries including India. Developing suitable models to enable us to understand how to control the problem of water pollution with which kind of treatment method is of crucial interest. Phytoremediator macrophytes decontaminate even the metallic pollutants which initially accumulate heavy metals to their roots through phosphate uptake pathway and then translocate to the above ground parts (Rahman and Hasegawa, 2011).

There are many factors to be considered to evaluate the treatment efficiency of any method like the presence and extent of reduction in the levels of total solids which mostly contribute to BOD and COD levels, and nutrient contents like nitrates, chlorides, phosphates. In the present study the process of

Phytoremediation with the use of local macrophyte plant *Cyperus esculents L* was examined to remove pollutants from the municipal sewage as phytoremediation has become an increasingly recognized pathway for contaminant removal from waste waters and polluted soils in recent periods. It was preferred to study as this technique is widely being accepted because of its aesthetically pleasing nature, solar-driven operation, and passive technique useful for remediation of sewage, contaminated waters and industrial effluents (Huang et.al., 2013).

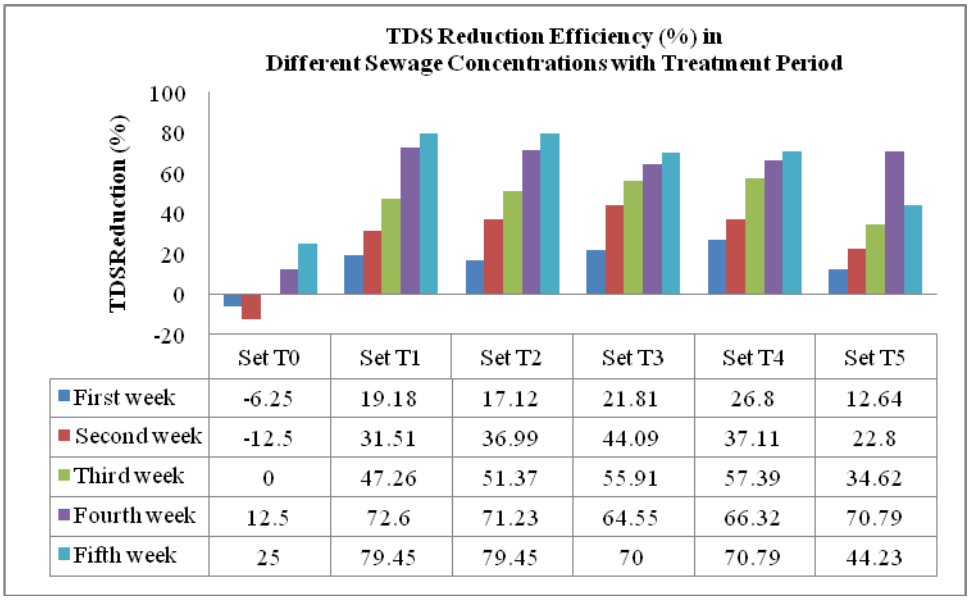
Traditionally, the variation of organic substances during phytoremediation are the commonly studied with water quality metrics such as chemical oxygen demand (COD) and biochemical oxygen demand (BOD) (Calheiros et al., 2007). Therefore, these parameters were preferred in this work. The phytoremediation potentiality of *Cyperus articulatus* naturally growing in industrial wastewater was tested for metal removal and found effective (Farrag and Fawzy, 2012) which is in good agreement with the present investigation for pollution reduction.



	Set T0	Set T1	Set T2	Set T3	Set T4	Set T5
First week	-16.67	43.52	8.41	11.8	2.35	24.44
Second week	-25	47.22	24.77	30.43	13.18	31.95
Third week	-8.33	64.35	51.4	52.17	21.65	39.85
Fourth week	8.33	77.77	60.75	62.73	48.47	45.11
Fifth week	25	78.7	75.7	70.19	52.94	47.18

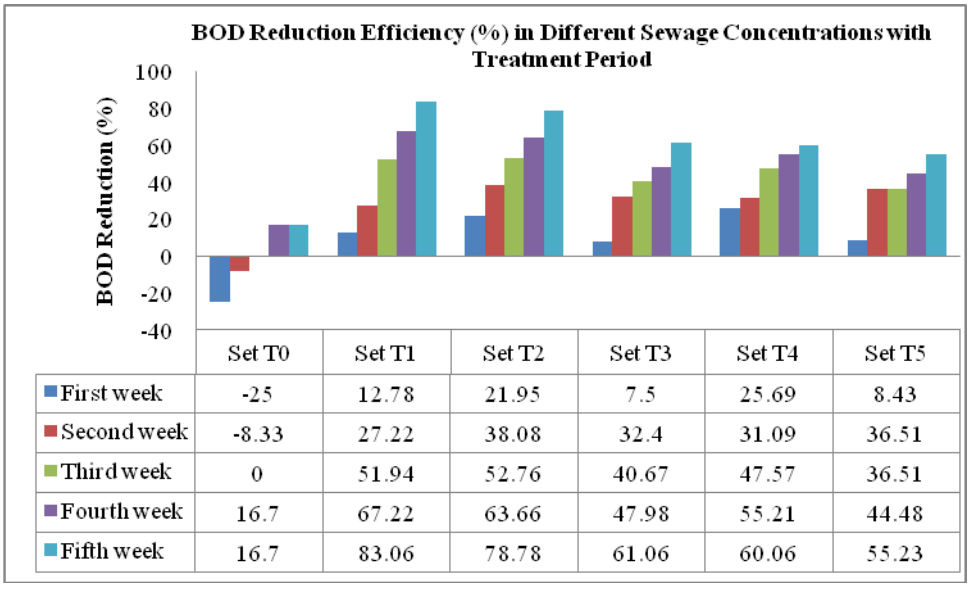
Fig.3: Comparative Reduction (%) in TSS contents in Different Sewage

Treatment Sets with Period of Treatment.



	Set T0	Set T1	Set T2	Set T3	Set T4	Set T5
First week	-6.25	19.18	17.12	21.81	26.8	12.64
Second week	-12.5	31.51	36.99	44.09	37.11	22.8
Third week	0	47.26	51.37	55.91	57.39	34.62
Fourth week	12.5	72.6	71.23	64.55	66.32	70.79
Fifth week	25	79.45	79.45	70	70.79	44.23

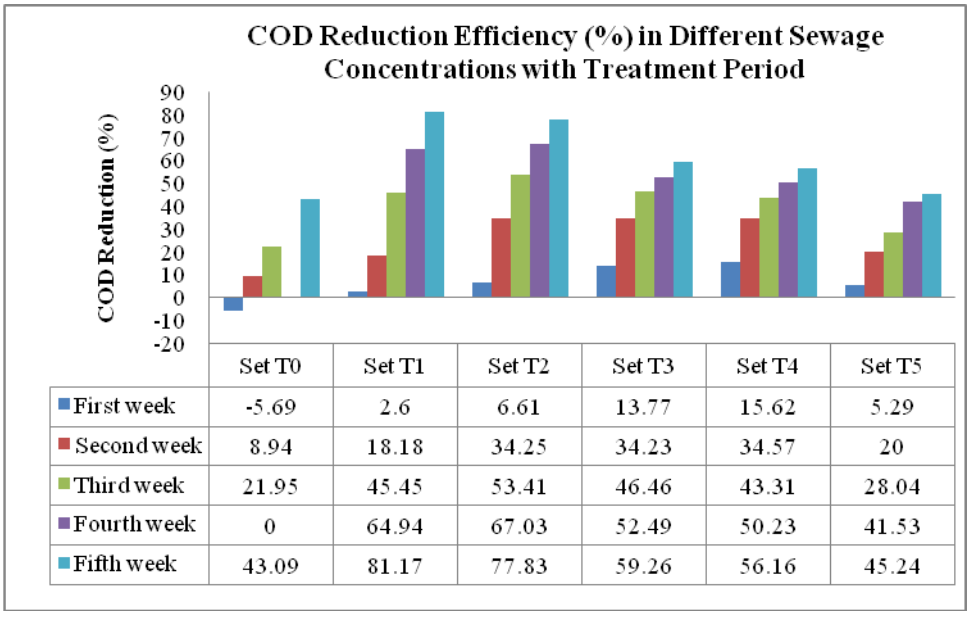
Fig.4: Comparative Reduction (%) in TDS Contents in Different Sewage Treatment Sets with Period of Treatment.



	Set T0	Set T1	Set T2	Set T3	Set T4	Set T5
First week	-25	12.78	21.95	7.5	25.69	8.43
Second week	-8.33	27.22	38.08	32.4	31.09	36.51
Third week	0	51.94	52.76	40.67	47.57	36.51
Fourth week	16.7	67.22	63.66	47.98	55.21	44.48
Fifth week	16.7	83.06	78.78	61.06	60.06	55.23

Fig.5: Comparative Reduction (%) in BOD levels in Different Sewage

Treatment Sets with Period of Treatment.



	Set T0	Set T1	Set T2	Set T3	Set T4	Set T5
First week	-5.69	2.6	6.61	13.77	15.62	5.29
Second week	8.94	18.18	34.25	34.23	34.57	20
Third week	21.95	45.45	53.41	46.46	43.31	28.04
Fourth week	0	64.94	67.03	52.49	50.23	41.53
Fifth week	43.09	81.17	77.83	59.26	56.16	45.24

Fig.6: Comparative Reduction (%) in COD levels in Different Sewage Treatment Sets with Period of Treatment.

Table 1: Treatment Efficiencies in Different Sets of Sewage Treated at various Concentrations using *Cyperus esculentus L* after 35 days.

Parameters	**Set T_0 (No Sewage)**	**Set T_1 (20% Sewage)**	**Set T_2 (40% Sewage)**	**Set T_3 (60% Sewage)**	**Set T_4 (80% Sewage)**	**Set T_5 (100% Sewage)**
pH	0	2.74	2.73	2.7	4.05	5.33
EC (µS/cm)	5.4	5.7	4.5	9.13	6.57	0.5
TSS (mg/L)	25	78.7	75.7	70.18	52.94	47.18
TDS (mg/L)	25	79.45	79.45	70	70.79	44.23
TS (mg/L)	25	79	77.22	70.11	60.19	45.64
BOD (mg/L)	16.66	83.33	78.77	61.05	60.05	55.23
COD (mg/L)	43.08	81.16	77.82	59.26	56.16	45.23
NO_3(mg/L)	54.54	81.39	68.96	59.23	54.85	40.9
PO_4(mg/L)	50	80	69.91	57.67	60.31	40.78
SO_4(mg/L)	72.72	41.7	70.05	71.89	53.99	40
Cl (mg/L)	20	59.94	54.83	42.02	24.93	18.01

Many recent studies have highlighted phytoremediation as an effective way to reduce the content of organic matter, nutrients and heavy metals in polluted waters and hence it is commonly regarded as a green technology (Hadad et al., 2006; He et al., 2008; Valipour et al., 2009) to which the present work is in good agreement. Phytoremediation is a novel bioremediation technology in which macrophytes are employed for the removal or degradation of complex environmental contaminants and metal pollutants (Cunningham et al., 1997; Meagher, 2000; Stottmeister et al., 2003). On this line, *Cyperus esculentus L* is successfully tested. This technique is also cost effective, sustainable, ecologically advantageous, aesthetically pleasing and is easily acceptable, in fact often welcomed by the general public due to its significant improvement of the anthropogenically impacted landscape (Trapp and Karlson, 2001). These views are supported by the present innovative development.

Conclusions

Macrophyte *Cyperus esculentus L* Plants in Floating Constructed Wetland Reactor Beda were designed for rational applications and thus provided a well treatment environment for sewage treatment. *Cyperus esculentus L* grew well at all concentrations of sewage. The results revealed that the design of Floating Constructed Wetland Reactor Systems are perfectly suitable for phytoremediation treatment of sewage using *Cyperus esculenta L* at all concentrations, with highest efficiency at about 40% concentration in terms of TSS, TDS, BOD and COD removal. It concluded that Phytoremediation with *Cyperus esculenta L.*using Floating Constructed Wetland Reactor system is an effective way to remove organic matter from the sewage.

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